Physics 230

Homework Set 7

1. An observer in a spaceship moving at a speed $V = (12/13)c$ relative to our frame of reference starts their stopwatch just as the spaceship passes the origin of our frame of reference. 1.0 hours pass by on the spaceship's stopwatch when position measurements are made.
   a) What are the two relevant events in this problem? Which observer measures $\Delta x' = 0$?
   b) Staying consistent with the notation in part a), draw two distinct images showing these two events from our reference frame. These images must show the two coordinate systems, labeled S and S', the relative motion of the frames, and should indicate the location of the events.
   c) Suppose that at the moment when the spaceship passed the origin of our reference frame, we too started our stopwatch. How much time passed by on our stopwatch when the spaceship's stopwatch read 1.0 hours?
   d) How much distance has the spaceship traveled within the aforementioned time interval, according to our frame of reference? Express your answer in units of c·hrs.
   e) How much distance has the spaceship traveled within the aforementioned time interval, according to the spaceship? Again, express your answer in units of c·hrs.

2. A spaceship passes earth traveling at a speed $V = (5/13)c$ and is heading for a distant planet 25 c·years away. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when the spaceship passes earth. Just as the spaceship passes earth, the spaceship observer sets his clock to also read zero.
   a) How much time has passed on the distant planet clock when the spaceship arrives?
   b) How much time has passed on the spaceship clock when the spaceship arrives?
   c) How far apart are the earth and the distant planet, according to the spaceship frame? Express your answer in units of c·years.

3. A spaceship passes earth traveling at a speed $V = (5/13)c$ and is heading for a distant planet 25 c·years away. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when the spaceship passes earth. Just as the spaceship passes earth, the spaceship observer sets his clock to read zero.

   Here we're interested in obtaining the earth clock reading when the distant planet arrives at the spaceship.

   a) What are the two relevant events in this problem? Which observer measures $\Delta x' = 0$?

   b) Staying consistent with the notation in part a), draw two distinct images showing these two events from the spaceship's reference frame. These images must show the two coordinate systems, labeled S and S', the relative motion of the frames, and should indicate the location of the events.

   c) What is the rest length distance between these two events? Who measures this length?

   d) In the spaceship's frame of reference, what will the earth clock read when the spaceship arrives?

4. A spaceship passes earth traveling at a speed $V = (5/13)c$ and is heading for a distant planet 25 c·years away. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when the spaceship passes earth. Just as the spaceship passes earth, the spaceship observer sets his clock to read zero. Precisely when the spaceship arrives at the distant star, a light signal from the earth indicates that the earth has exploded.

   a) Draw a set of three pictures, in the rest frame of the earth and distant planet, for these three events (the spaceship's departure, the sending of the light signal, and the spaceship's arrival at the distant planet/spaceship receiving the light signal).

   b) At the moment when the signal is sent, what time does the earth clock read?

   c) At the moment when the signal is sent, what times does the spaceship clock read?

5. A spaceship passes earth traveling at a speed $V = (5/13)c$ and is heading for a distant planet 25 c·years away. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when the spaceship passes earth. Just as the spaceship passes earth, the spaceship observer sets his clock to read zero. Precisely when the spaceship arrives at the distant star, a light signal from the earth indicates that the earth has exploded.
   a) Draw a set of three pictures, in the rest frame of the spaceship, for these three events (the earth's departure, the sending of the light signal, and the distant planet's arrival at the spaceship/spaceship receiving the light signal).
   b) According to the spaceship observers, what is the spatial separation between the earth and the distant planet?
   c) According to the spaceship observers, what does the spaceship clock read when the distant planet arrives at the spaceship?
   d) According to the spaceship observers, what does the earth clock read when the distant planet arrives at the spaceship?

6. A K^+ meson is created using the Large Hadron Collider (LHC) in Europe. In its own rest frame the K^+ meson decays into two π mesons in a time of 1.25×10^{-8} s.
   a) How fast is the K^+ meson traveling, relative to the LHC's lab frame, if it moves a distance of 10.0 m before decaying?
   b) What is the lifetime of the aforementioned K^+ meson according to the LHC scientists?